Introduction to Soils

Overview

- The purpose of this lesson is to familiarize you, the student, with the classifications, testing procedures, stabilization methods, and dust abatement methods used for soils.

Learning Objectives

- Terminal Learning Objectives
- Enabling Learning Objectives

Method / Media

- Lecture Method
- Power Point Presentation
- Video
- Demonstrations
- Practical Applications

Evaluation

- A twenty-five question, multiple choice written exam.

Safety / Cease Training

- Vehicle Safety
- Sunburn
- Drink Water
- Bug Spray

- In the event of a casualty, all students will go back to the classroom and wait for further instruction.

Transition

- Are there any questions over:
  - What will be taught?
  - Methods used for teaching?
  - Evaluation method?

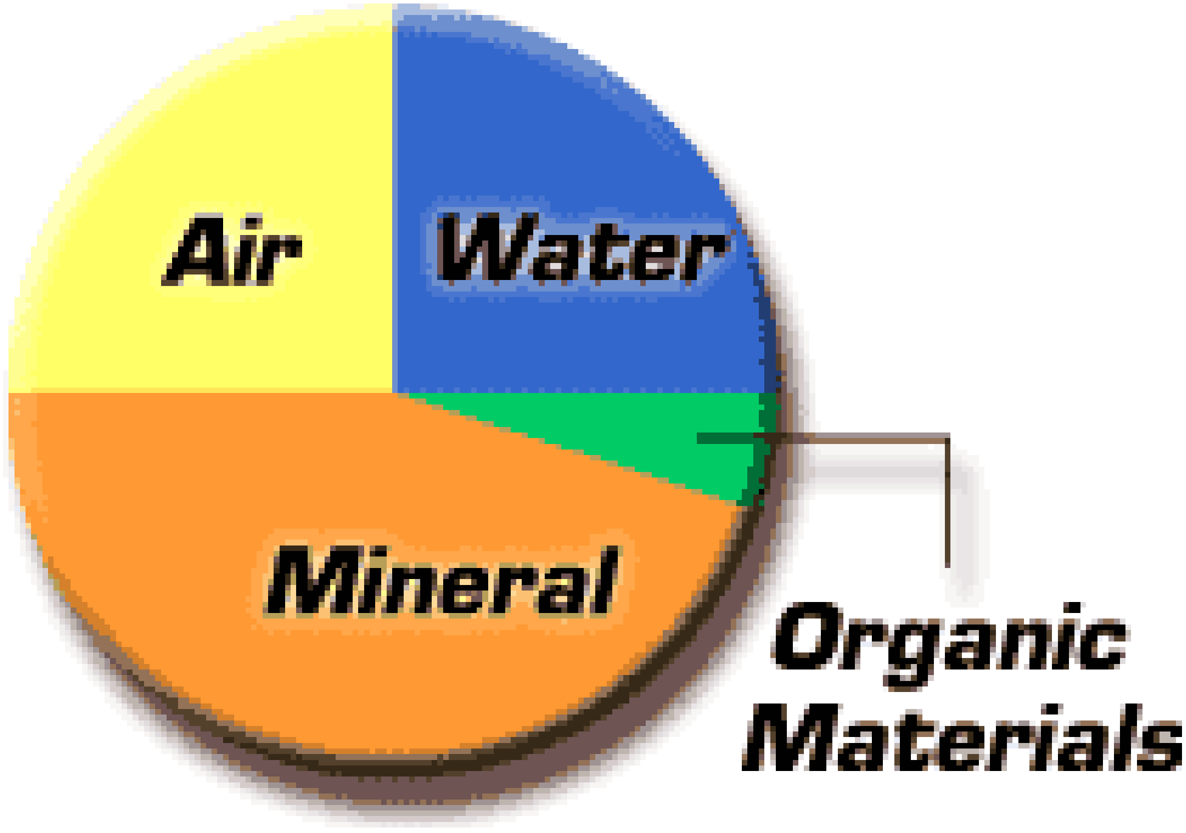
Soil Basics

- Collecting the sample.

Definition of Soil

- Soil is defined as the entire unconsolidated material that overlies and is distinguishable from bedrock.
- Composed of loosely bound mineral grains of various sizes and shapes.
- Contains voids of varying sizes. These voids contain:
  - Air
  - Water
  - Organics

Composition of Soil



Soil Formation

- The principle factor influencing soil formation is Weathering.

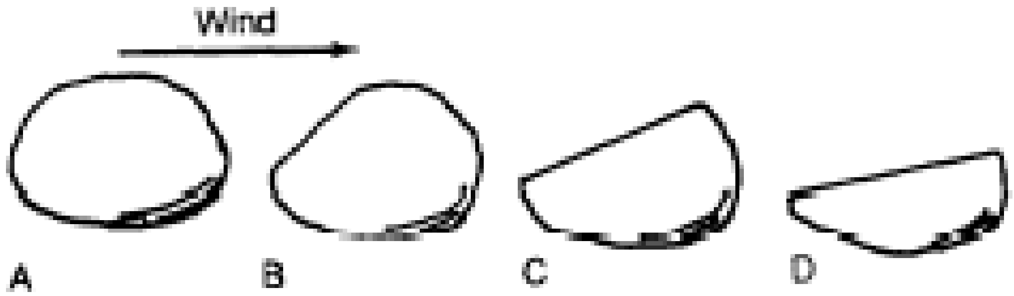
Weathering

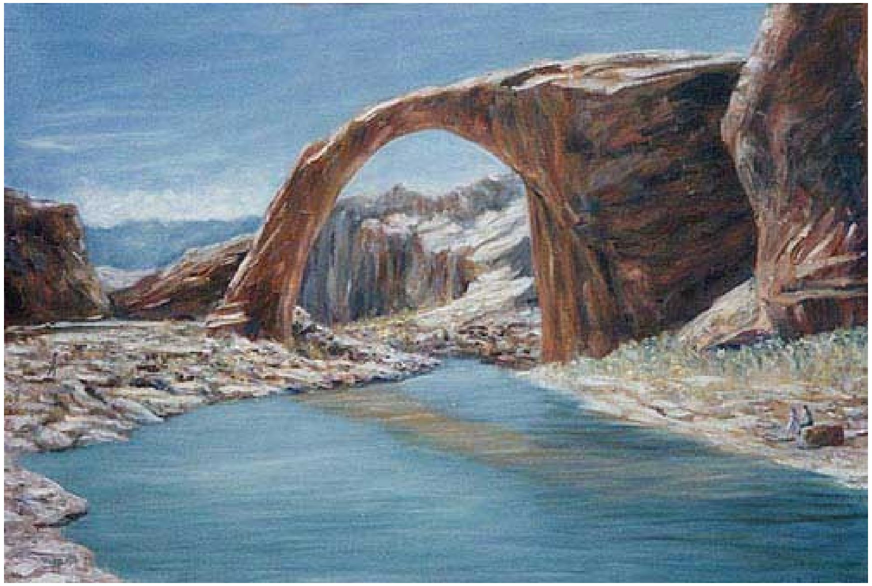
- Defined as the process by which rock is converted into soil.
- Two types of weathering:
  - Mechanical
  - Chemical

Mechanical Weathering

- Unloading – removal of overlying material
- Frost Action – up to 4000 psi
- Organism Growth – growth inside of joints causes wedging effect
- Abrasion - friction
  - Wind
  - Water

Wind and Water Abrasion





Chemical Weathering

- Decomposition of rock through chemical bonding
- Examples include:
  - Hydration (combining with water)
  - Oxidation
  - Carbonation (saturation with carbon dioxide)

Engineering Properties of Soil

- Varies greatly depending on its physical properties, however, the behavior of a soils not exclusively dependant on physical properties.
- Also dependant on arrangement of particles (Compaction)

KSE K-2009 SOIL TEST SET

LABORATORY

SPEEDY MOISTURE TESTER

DYNAMIC CONE PENETROMETER

Laboratory Test Set

#4, 40, 200 Sieves

Mixing Bowls, mortar, & pestles, trowels

Halogen water bottles

Scale, spatula, towels, brush

USACE Cone Penetrometer, water jug, printer

Speedy Moisture Kit

Dynamic Cone Penetrometer

Rod Assembly & Dual Mass Hammer

Set Pins & Clips, Allen Wrench

Magnetic ruler w/ Digital Assembly

Dynamic Cone Penetrometer

Cone Adapter

Disposable Tips

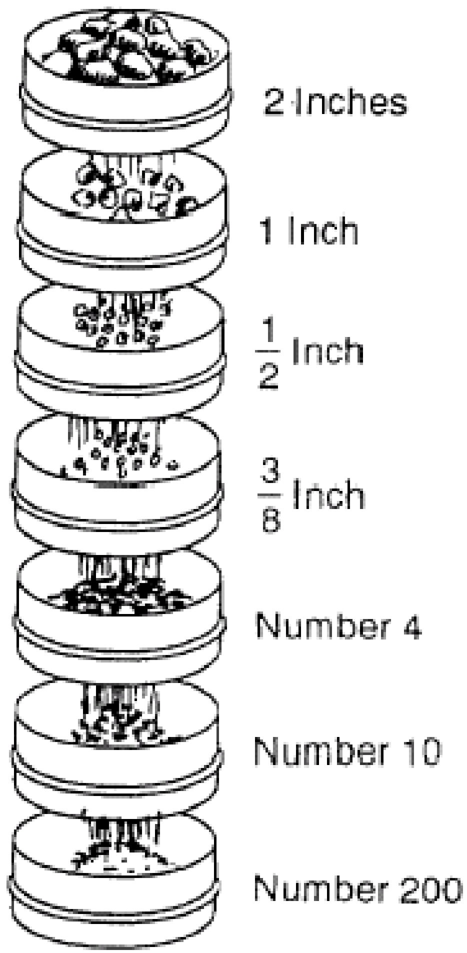
Users Manual (CD)

Drive Rod

Grain Size

- Four major categories:
  - Cobbles – greater than 3”
  - Gravels – Passes a 3” sieve and retained on No.4 sieve (approx 0.25”)
  - Sands – Passes No.4 sieve and retained on No. 200 sieve (0.072 mm)
  - Fines – Passes No.200 sieve

Dry Sieve Analysis



Grain Size Groups

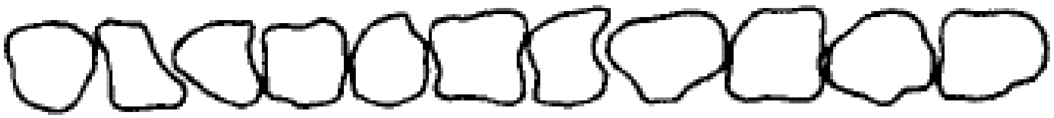
Size Group	Sieve Size	
	Passing	Retained On
Cobbles	No Maximum Size	3 inches
Gravels	3 inches	No. 4 (□0.25 inches)
Sands	No. 4 (□0.25 inches)	No. 200 (0.072 mm)
Fines (silt or clay)	No. 200 (0.072 mm)	No minimum Size
In military engineering, the maximum size of cobbles is accepted as 40 inches, based on the maximum jaw opening of a rock-crushing unit.		

Gradation

- Distribution of particles within a soil.
- Soils are either:
  - Well graded – good distribution of particle sizes
  - Poorly graded – bad distribution of particles sizes
    - Uniformly graded – only one soil size
    - Gap graded – missing soil sizes

Soil Gradations

Well Graded



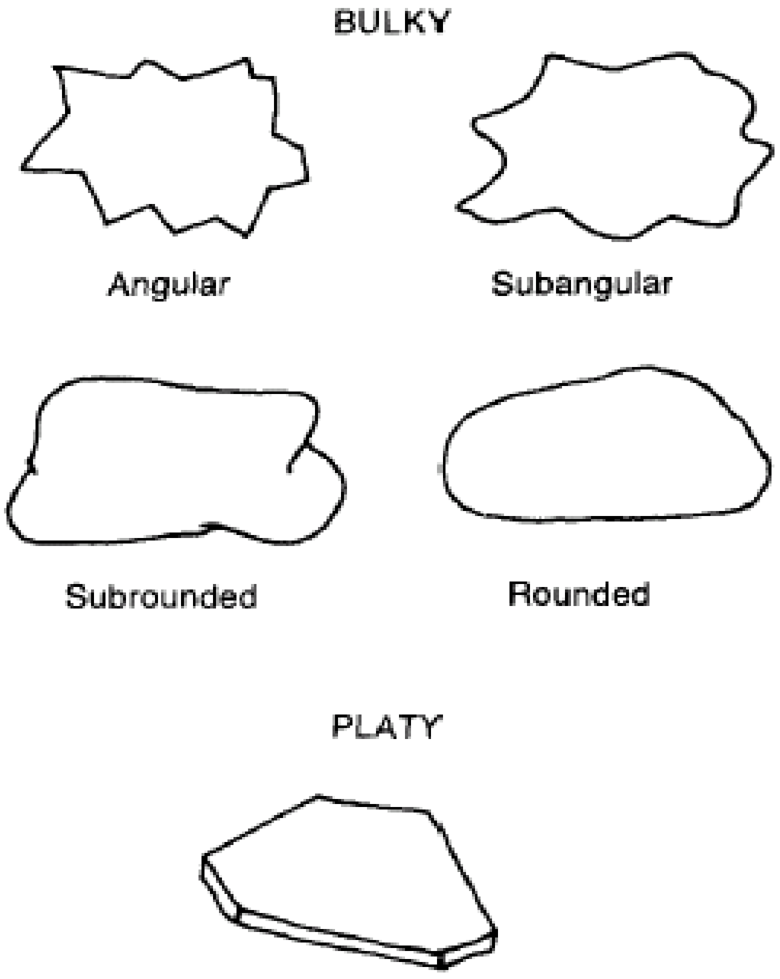
Uniformly Graded

Gap Graded

Grain Shape

- Influences a soils strength and stability
- Two general shapes:
  - Bulky – three dimensional
    - Angular – recently been broken
    - Sub angular – sharper points and edges are worn
    - Sub rounded – further weathered than sub angular
    - Rounded – no projections and smooth in texture
  - Platy – two dimensional

Soil Particle Shapes



Density

- Determined by the ratio of voids (air and water) to soil particles.
- A denser soil has greater strength and stability than a looser soil.

Moisture

- Most important factor affecting engineering characteristics.
- Moistures affect varies greatly depending on soil type:
  - Course grained soils usually remains unchanged.
  - Fine grained soils are susceptible to shrinking and swelling.

Plasticity and Cohesion

- Plasticity is the ability of a soil to deform without cracking.
- Fine grained soils, like clay, have a wide range of plasticity.
- Coarse grained soils, like clean sands and gravels, are non plastic

Concepts of Soils Engineering

- Settlement
- Shear Resistance
- Soil Failure

Settlement

- Soil settlement is dependent on:
  - Density
  - Grain size and shape
  - Structure
  - Past loading history of the soil deposit
  - Magnitude and method of application of the load
  - Degree of confinement of the soil mass

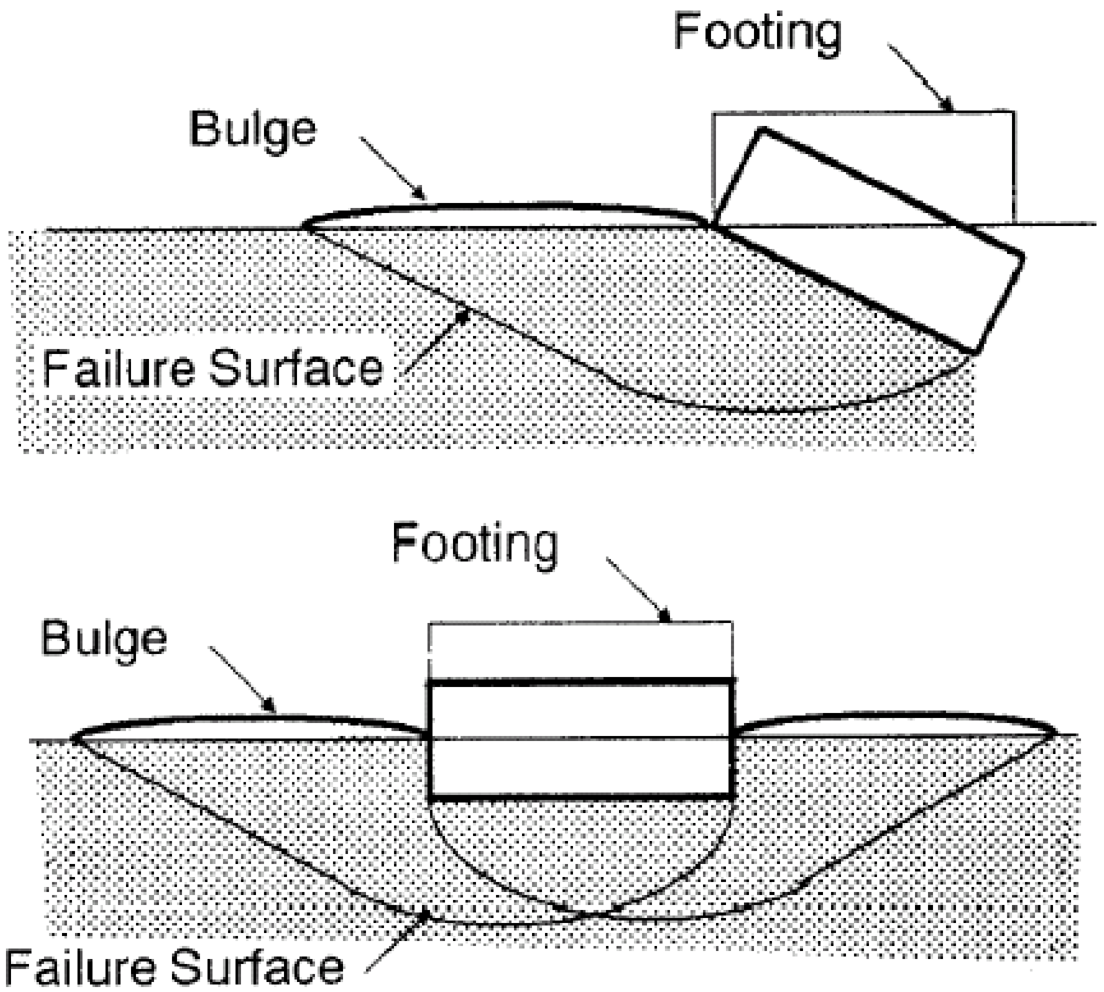
Shear Resistance

- Related to a soils ability to withstand loads.
- California Bearing Ratio (CBR) is a measure of shearing resistance
  - CBR is a soil's ability to support a load relative to that of soil with known strength (limestone).
  - Determined by the Soils Test Kit (B2150)

Bearing Capacity

- The ability of a soil to support a load applied by an engineering structure.
- A soil with insufficient bearing capacity might fail, by shear, allowing the structure to sink and shift.
- Dense and well graded soil with angular particles generally has good bearing capacities.

Soil Failure



Soil Classification

Introduction

- The principle objective of any soil classification system is predicting the engineering properties and behavior of a soil.
- This is achieved with simple laboratory and field tests.
- These tests results place a soil into a group of similar soils.

Unified Soils Classification System

- Based on the characteristics of the soil which affect its engineering properties.
- Basic classification considerations:
  - % of gravels, sands, and fines
  - Gradation of the soil
  - Plasticity and compressibility of the soil

USCS Soil Categories

- Coarse grained soils – less than 50% fines
  - Gravels and gravelly soils
  - Sands and sandy soils
- Basic classification considerations:
  - Fine grained soils – more than 50% fines
    - Silts (0.05mm to 0.005mm)
    - Clays (smaller than 0.005mm)
    - Organics
- Highly organic soils (peat)

USCS Soil Groups

- A symbol is assigned to each soil category, and categories can be combined to create a two letter designator.

USCS Soil Symbols

Soil Groups	Symbol	Remarks
Gravel	G	Primary only
Sand	S	Primary only
Silt	M	Primary and secondary
Clay	C	Primary and secondary
Organic (silts or clays)	O	Primary only
Highly Organic (peat)	Pt	Stands alone
Soil Characteristics	**Symbol**	**Remarks**
Well graded	W	Secondary only
Poorly graded	P	Secondary only
Low liquid limit (less than 50)	L	Secondary only
High liquid limit (50 or greater)	H	Secondary only

Possible USCS Soil Types

- GW – gravel, well graded
- GP – gravel, poorly graded
- GM – silty gravels
- GC – clayey gravels
- SW – sand, well graded
- SP – sand, poorly graded

Possible USCS Soil Types

- SM – silty sands
- SC – clayey sands
- ML – silts, low plasticity
- CL – clays, low plasticity
- OL – organics, low plasticity
- MH – silts, high plasticity

Possible USCS Soil Types

- CH – clays, high plasticity
- OH – organics, high plasticity
- Pt – peat and other highly organic soils

Other Soil Terms

- Loam – mix of clay, sand, and organics

Soil Compaction

Purpose of Compaction

- Most critical component in horizontal construction.
- Durability and stability of structures is related to proper compaction.
- Structural failure can often be traced to improper compaction.

Effects of Soil Compaction

- Settlement – Compaction brings a closer arrangement of soil particles which, in turn, reduces settlement.

- Shearing Resistance – Increasing soil density usually increases shearing resistance.

Effects of Soil Compaction

- Water Movement – Compaction decreases the size and number of voids leaving less room for water.
- Volume Change – Generally not of great concern except with clayey soils.

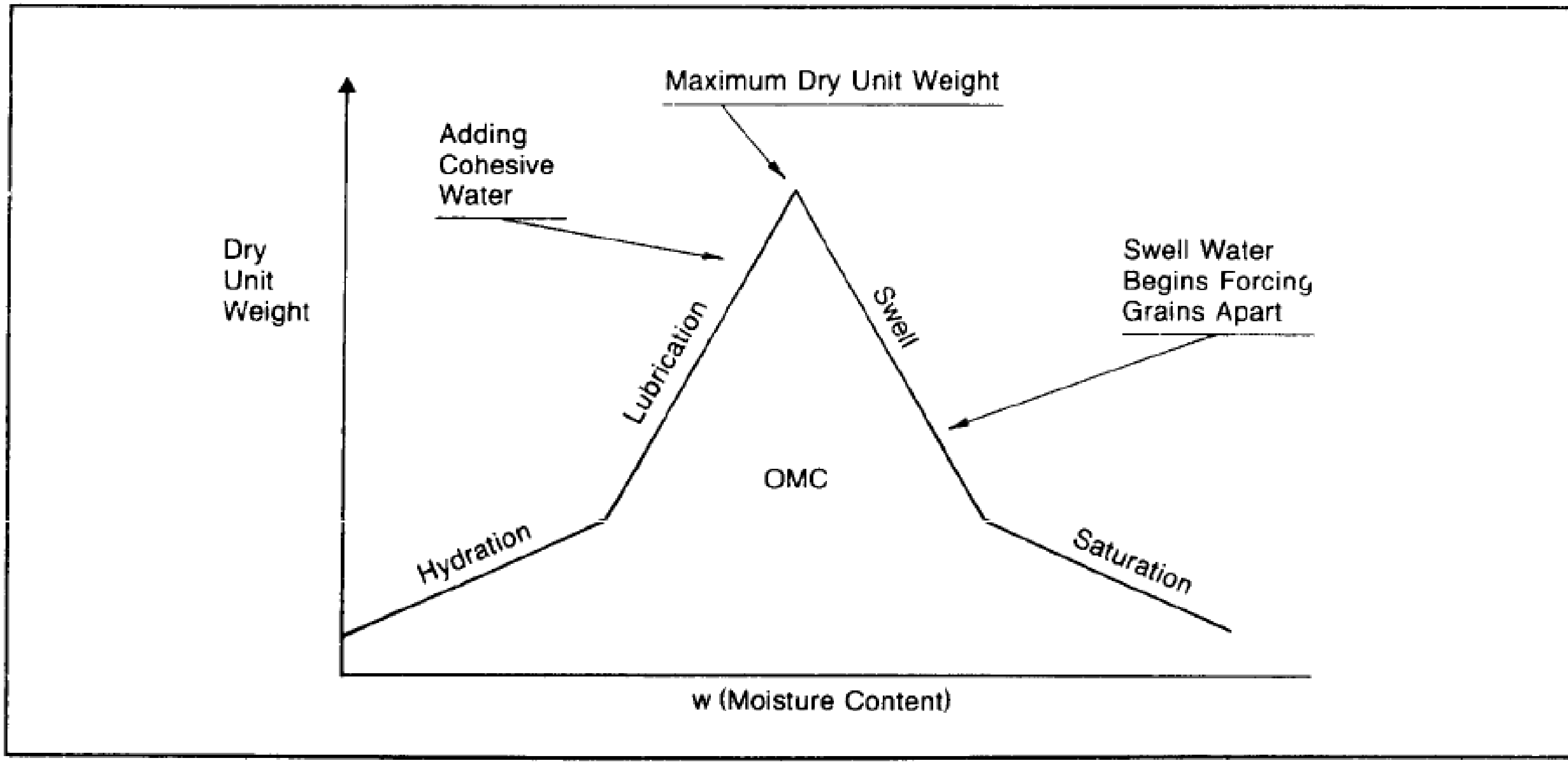
Design Considerations

- The degree of compaction that can be achieved is dependant on its physical and chemical properties; however, several common factors influence compaction of all soils.

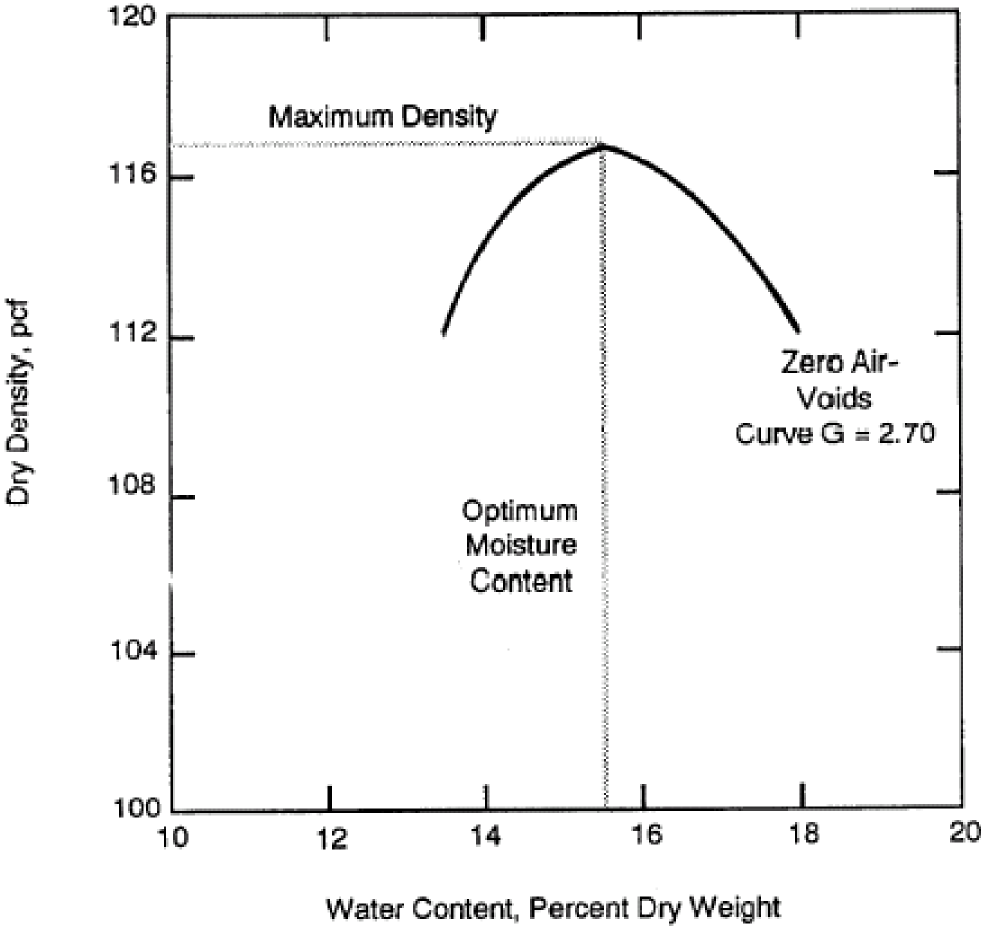
Moisture Content

- The moisture content has a great impact on a soils ability to densify.
- Optimum Moisture Content (OMC) – the percentage of water, at which a soil will achieve maximum dry density (MDD) under a given compactive effort.
- When at MDD, most of the air voids have been expelled from the soil.

Effect Of H2O on Density



Typical H2O-Density Relationship



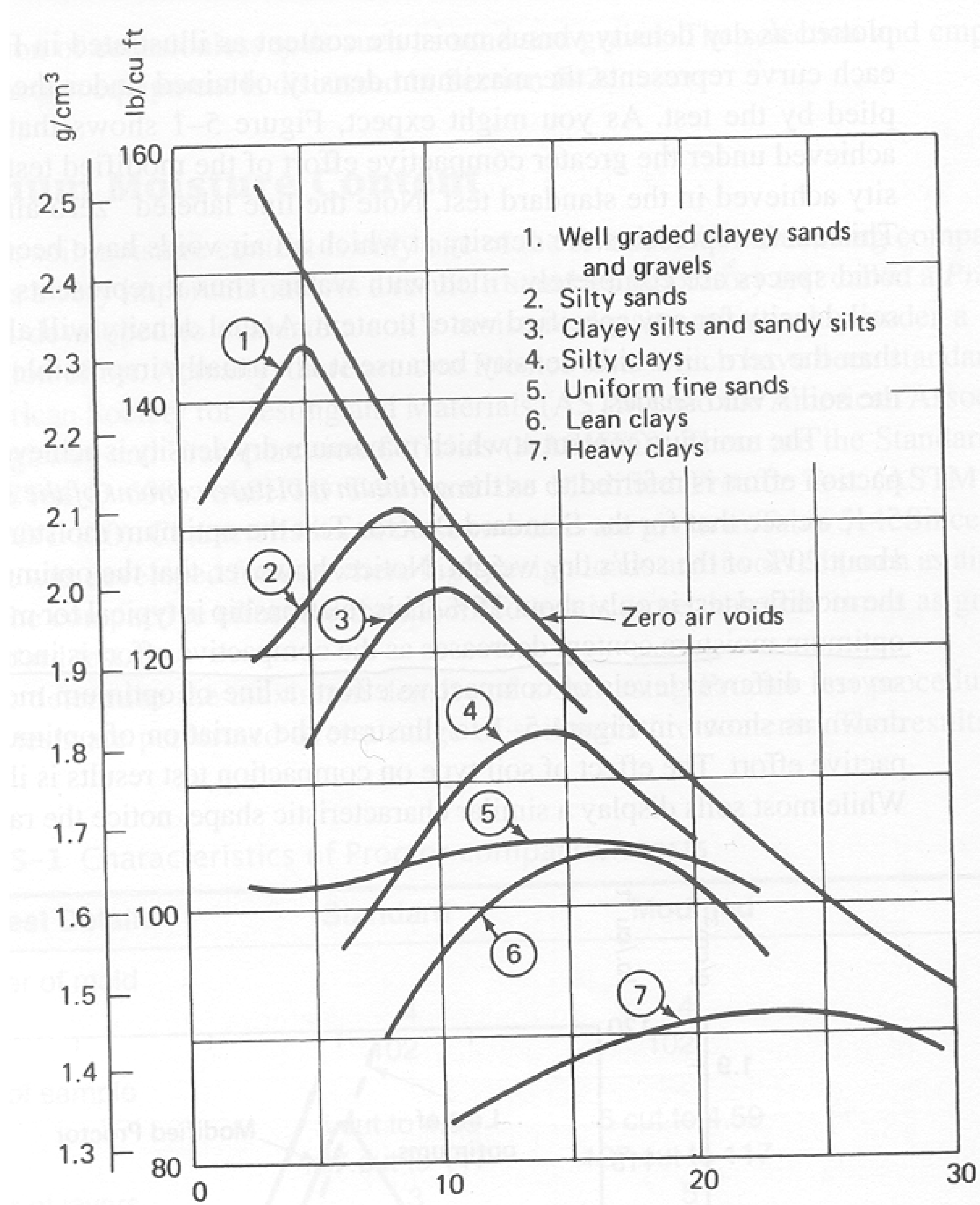
Compaction Characteristics of Various Soils

- The nature of a soil has an effect on its response to compaction.
- Light weight soils can have maximum densities under 60 pcf under a given compactive effort.
- The same compactive effort applied to clay could yield 90 to 100 pcf.

Compaction Characteristics of Various Soils

- Well graded soils can yield maximum densities up to 135 pcf under a given compactive effort.

Compaction Characteristics of Various Soils



Selection of Materials

- Use the indigenous material from cut sections of the road as much as possible.

- Tables 13, 14, and 15 provide a listing of soil types and the value as construction materials.

Soil Stabilization

Introduction

- Soil Stabilization is the alteration of one or more soil properties, by mechanical or chemical means, to create an improved soil material possessing the desired engineering properties.
- Typically, soil stabilization seeks to alter texture, gradation, or plasticity.

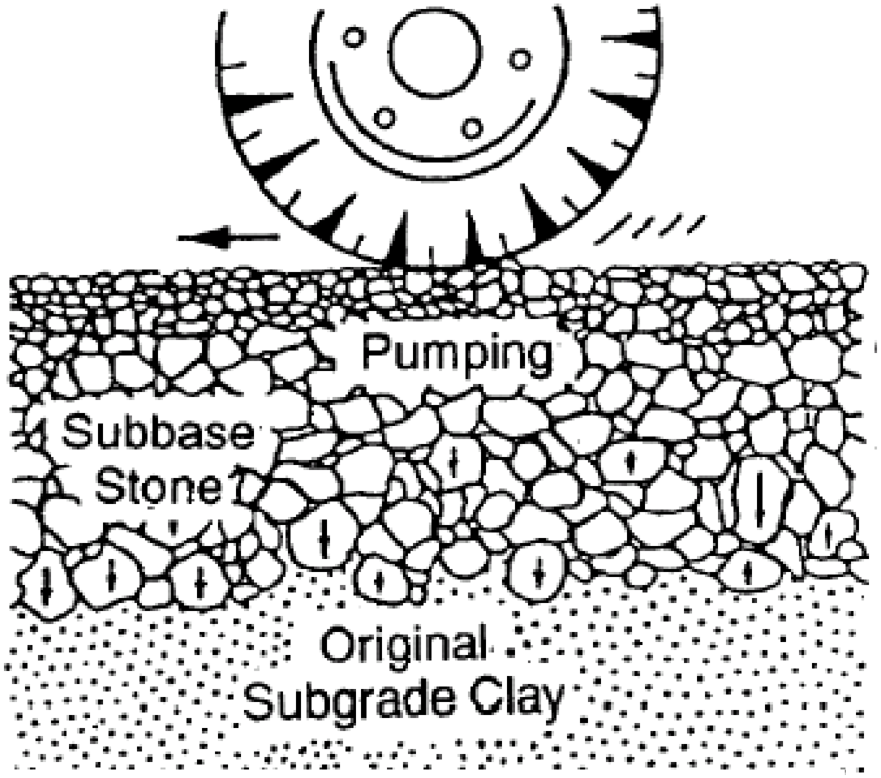
Stabilization Techniques

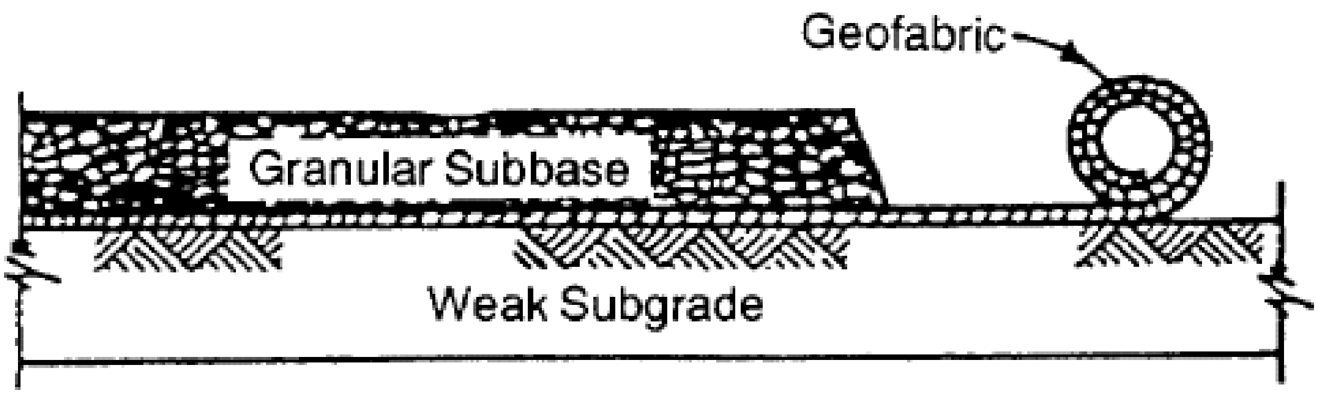
- Geotextiles
- Mechanical Stabilization
- Chemical Stabilization

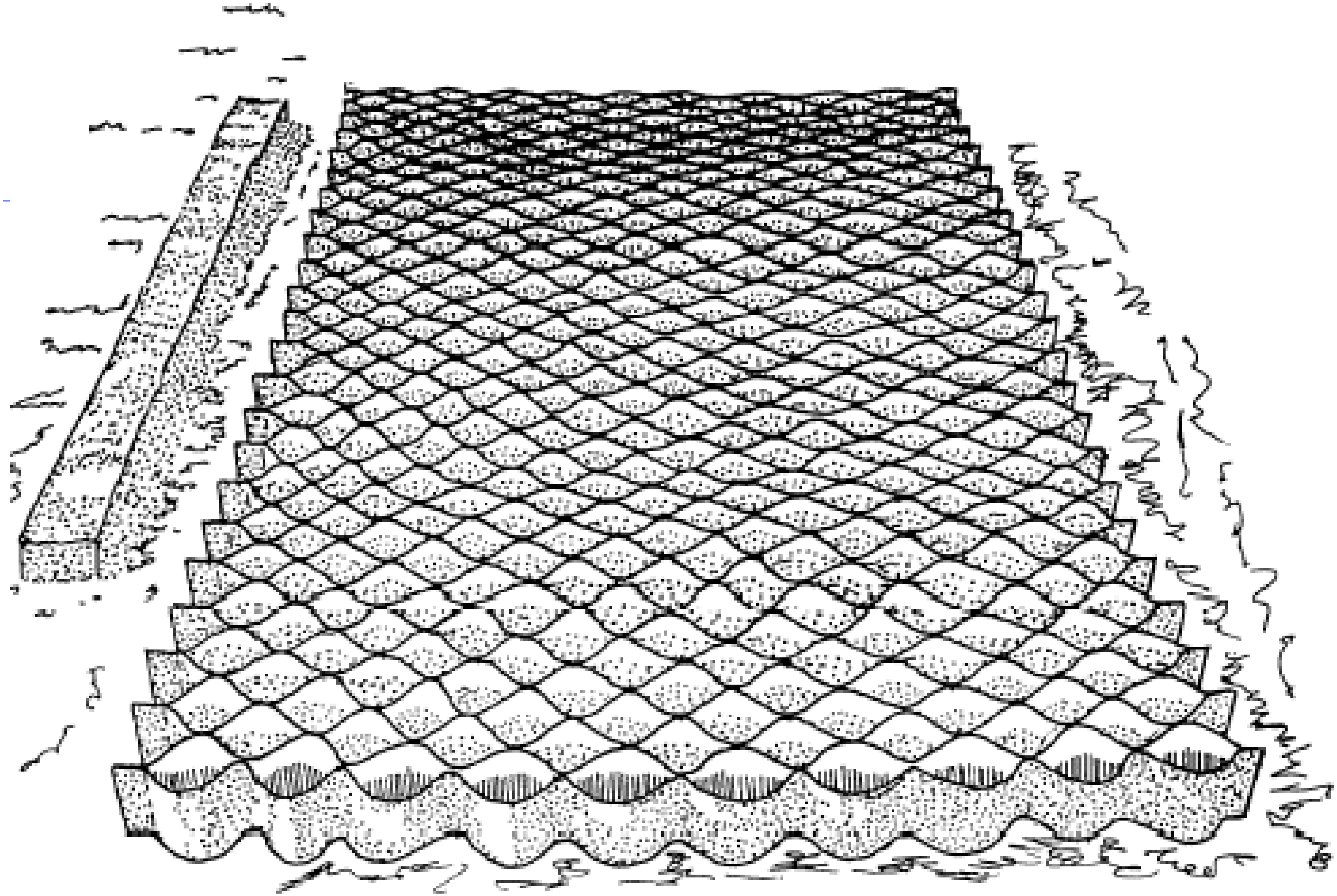
Geotextiles

- Geotextiles serve three primary functions:
  - Reinforcement – Good in low load bearing soils such as swamps and peat bogs.
  - Separation – Separates weaker layers in a project.
  - Drainage – Allows water to pass while preventing soil particle movement.

Geotextiles Separation







Mechanical Stabilization

- Mechanical Stabilization is the blending of one or more soil types with in place soil to obtain a material the will have engineering properties better than that of the other.
- Does not include compaction.

Chemical Stabilization

- Chemical Stabilization is adding granular or chemical admixtures to a soil.
- Used when an inadequate soil is too costly to remove and replace
- Common methods are:
  - Portland Cement
  - Lime
  - Fly-Ash
  - Mixtures
  - Bituminous

Chemical Stabilization

- Portland Cement
  - Transforms the soil into a cemented mass increasing strength and durability
  - Good for a wide range of materials

Portland Cement

Soil Classification	Initial Estimated Cement Requirement, Percent Dry Weight
GW,SW	5
GP,SW-SM,SW-SC	6
GW-GM,GW-GC	6
GM,SM,GC,SC,SP-SM,SP-SC,GP-GM,GP-GC,SM-SC,GM-GC	7
SP,CL,ML,ML-CL	10
MH-OH	11
CH	10
*Table extracted from FM 5-410, page 9-15.	

Chemical Stabilization

- Lime
  - Reacts with medium to fine grained soils to decrease plasticity
  - Not normally used with SW,SP, GW, or GP because of the low amount of fines
  - The increased plasticity increases strength and reduces shrinkage and swell

Chemical Stabilization

- Fly-Ash
  - By-product of coal fired electric power plants
  - Reacts with lime and water to produce a strong, slow-hardening cement
  - Capable of high compressive strengths

Chemical Stabilization

- Mixtures (if materials are available)
  - Lime/Fly-ash
  - Lime/Cement/Fly-ash
    - Expedient mix:

      1% Cement

      4% Lime

      16% Fly-ash

      79% Soil

Chemical Stabilization

- Bituminous
  - Not normally available to the Marine Corps
  - Types include:
    - Asphalt cement
    - Cutback asphalt
    - Asphalt emulsions

Dust Abatemen

What is Dust?

- Dust is simply soil particles which have become airborne.
- Generally, dust are those particles which pass the #200 sieve.

What is Dust?

- Causes of dust:
  - Wind
  - Physical Abrasion
    - Vehicles
    - Foot Traffic

What is Dust?

- Dust is typically a problem with sandy soils of greater than 10% fines
- Soils with 10% to 40% fines are the most difficult to deal with
- Soils with greater than 40% fines generally respond the best to dust abatement products

Factors Influencing Dust

- Soil texture and structure
- Soil moisture content
- Presence of salts and organic matter
- Smoothness of the ground cover

Factors Influencing Dust

- Vegetation cover
- Wind velocity and direction
- Humidity

Dust Control Methods

- Agronomic
  - Examples include:
    - Mulch
    - Sodding
    - Planting vegetation
  - Not normally used in traffic areas

Dust Control Methods

- Surface Penetrates
  - Applied to the soil surface and allowed to “seep” in
  - Examples include:
    - Bitumen's
    - Resins
    - Salts
    - Water
    - Polymers

Dust Control Methods

- Surface Blanket
  - Covers the soil to prevent dust
  - Examples include:
    - Aggregates
    - Geofabrics
    - Bituminous surface treatments

Dust Abatement Products

- Gretch
- EK-35
- EnviroKleen
- Tar
- Mobi-matting
- Tri-PAM
- Soiltac

Questions?